METHODS OF USE OF TBP-II BINDING ANTIBODIES

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a division of U.S. application no. 09/800,908, filed March 8, 2001, now issued as U.S. Patent 6,602,993, which is a division of 08/477,347, filed June 7, 1995, now issued as U.S. Patent 6,232,446, which is a continuation-in-part of U.S. application no. 07/930,443, filed on August 19, 1992, and U.S. application no. 08/450,972, filed May 25, 1995, now abandoned. The entire contents of said applications are hereby incorporated herein by reference. Application no. 07/930,443, filed on August 19, 1992, is a continuation of application no. 07/524,263, filed May 16, 1990, now abandoned. Application no. 08/450,972, filed May 25, 1995, is a continuation of application no. 08/115,685, filed September 3, 1993, now abandoned.

FIELD OF THE INVENTION

[0002] The present invention relates to ligands to Tumor Necrosis Factor receptors (TNF-Rs) which inhibit the effect of TNF but not its binding to the TNF-Rs, as well as to ligands interacting with other receptors of the TNF/NGF family.

BACKGROUND OF THE INVENTION

[0003] Tumor necrosis factor (TNF) is a pleiotropic cytokine, produced by a number of cell types, mainly by

activated macrophages. It is one of the principal mediators of the immune and inflammatory response. Interest in its function has greatly increased, recently, in view of evidence of the involvement of TNF in the pathogenesis of a wide range of disease states, including endotoxin shock, cerebral malaria and graft-versus-host reaction. Since many of the effects of TNF are deleterious to the organism, it is of great interest to find ways of blocking its action on host cells. An evident target for such intervention are the molecules to which TNF has to bind in order to exert its effects, namely the TNF-Rs. These molecules exist not only in cell-bound, but also in soluble forms, consisting of the cleaved extra-cellular domains of the intact receptors (see Nophar et al., EMBO Journal, 9(10):3269-78, 1990). The soluble receptors maintain the ability to bind TNF, and thus have the ability to block its function by competition with surface receptors.

[0004] Another method of TNF inhibition based on the principle of competing with cell-bound molecules, is the use of antibodies recognizing TNF receptors and blocking the ligand binding.

[0005] The cell surface TNF-Rs are expressed in almost all cells of the body. The various effects of TNF, the cytotoxic, growth-promoting and others, are all signaled by the TNF receptors upon the binding of TNF to them. Two forms of these

receptors, which differ in molecular size: 55 and 75 kilodaltons, have been described, and will be called herein p55 and p75 TNF-R, respectively. It should be noted, however, that there exist publications which refer to these receptors also as p60 and p80.

[0006] The TNF-Rs belong to a family of receptors which are involved in other critical biological processes. Examples of these receptors are the low affinity NGF receptor, which plays an important role in the regulation of growth and differentiation of nerve cells. Several other receptors are involved in the regulation of lymphocyte growth, such as CDw40 and some others. Another member of the family is the FAS receptor also called APO, a receptor which is involved in signaling for apoptosis and which, based on a study with mice deficient in its function, seems to play an important role in the etiology of a lupus-like disease. Herein, this family of receptors is called "TNF/NGF receptor family".

[0007] One of the most striking features of TNF compared to other cytokines, thought to contribute to the pathogenesis of several diseases, is its ability to elicit cell death. The cell-killing activity of TNF is thought to be induced by the p55 receptor. However, this p55 receptor activity can be assisted by the p75 receptor, through a yet unknown mechanism.

[0008] Parent application number 07/524,263 and European Patent publications 398,327 and 412,486 disclose antibodies to the soluble TNF-Rs. These antibodies were found to recognize the soluble TNF-Rs and to inhibit the binding of TNF to the TNF-Rs on the cell surface. Monovalent F(ab) fragments blocked the effect of TNF, while intact antibodies were observed to mimic the cytotoxic effect of TNF.

SUMMARY OF THE INVENTION

[0009] The present invention provides a ligand to a member of the TNF/NGF receptor family, which binds to the region or the C-terminal cysteine loop of such a receptor.

[0010] Preferably this region includes the amino acid sequence cys-163 to thr-179 in the p75 TNF-R or a corresponding region in another member of the TNF/NGF family.

[0011] Preferably, the receptor is the TNF-R, in particular the p75 TNF-R.

[0012] One such ligand includes the amino acid sequence for the CDR region of the heavy chain of monoclonal antibody no. 32, shown in Fig. 11 (SEQ ID NO:7), and/or the amino acid sequence for the CDR region of the light chain of this antibody shown in Fig. 12 (SEQ ID NO:11).

[0013] Another such ligand includes the amino acid sequence for the CDR region of the heavy chain of monoclonal antibody no. 70 (SEQ ID NO:5) shown in Fig. 11.

[0014] Yet another such ligand includes the amino acid sequence for the CDR region of the heavy chain of monoclonal antibody no. 57 (SEQ ID NO:9), shown in Fig. 11.

[0015] The above antibodies are called herein, for simplicity's sake, "group 32" antibodies.

[0016] In another aspect of the invention, the ligands comprise the scFv of a group 32 antibody.

[0017] The ligands may comprise, for example, proteins, peptides, immunoadhesins, antibodies or other organic compounds.

[0018] The proteins may comprise, for example, a fusion protein of the ligand with another protein, optionally linked by a peptide linker. Such a fusion protein can increase the retention time of the ligand in the body, and thus may even allow the ligand-protein complex to be employed as a latent agent or as a vaccine.

[0019] The term "proteins" includes muteins and fused proteins, their salts, functional derivatives and active fractions

[0020] The peptides include peptide bond replacements and/or peptide mimetics, i.e., pseudopeptides, as known in the art (see, e.g., Proceedings of the 20th European Peptide Symposium, ed. G. Jung, E. Bayer, pp. 289-336, and references therein), as well as salts and pharmaceutical preparations

Biology., Escom, Leiden (1991), pp. 268-270), and sometimes also receptor binding may be enhanced by forming cyclic analogues. An example of this is given in "Conformationally restricted thymopentin-like compounds", US Pat. 4,457,489 (1985), Goldstein, G. et al. Thirdly, the introduction of ketomethylene, methylsufide or retroinverse bonds to replace peptide bonds, i.e., the interchange of the CO and NH moieties are likely to enhance both stability and potency. An example of this type is given in the paper "Biologically active retroinverso analogues of thymopentin", Sisto A. et al in Rivier, J.E. and Marshall, G.R. (eds) Peptides, Chemistry, Structure and Biology", Escom, Leiden (1990), pp. 722-773).

[0022] The peptides of the invention can be synthesized by various methods which are known in principle, namely by chemical coupling methods (*cf.* Wunsch, E: "Methoden der organischen Chemiet", Volume 15, Band 1 + 2, Synthese von Peptiden, thime Verlag, Stutt (1974), and Barrany, G.; Marrifield, R.B.: "The Peptides", eds. E. Gross, J. Meienhofer, Volume 2, Chapter 1, pp. 1-284, Academic Press (1980)), or by enzymatic coupling methods (*cf.* Widmer, F. Johansen, J.T., Carlsberg Res. Commun., Vol.44, pp. 37-46 (1979), and Kullmann, W.: "Enzymatic Peptide Synthesis", CRC Press Inc. Boca Raton, Fl. (1987), and Widmer, F., Johansen, J.T. in "Synthetic Peptides in Biology and Medicines", eds.

and/or formulations which render the bioactive peptide(s) particularly suitable for oral, topical, nasal spray, ocular, pulmonary, I.V. or subcutaneous delivery, depending on the particular treatment indicated. Such salts, formulations, amino acid replacements and pseudopeptide structures may be necessary and desirable to enhance the stability, formulation, deliverability (e.g., slow release, prodrugs), or to improve the economy of production, as long as they do not adversely affect the biological activity of the peptide.

[0021] Besides substitutions, three particular forms of peptide mimetic and/or analogue structures of particular relevance when designating bioactive peptides, which have to bind to a receptor while risking the degradation by proteinases and peptidases in the blood, tissues and elsewhere, may be mentioned specifically, illustrated by the following examples: Firstly, the inversion of backbone chiral centres leading to D-amino acid residue structures may, particularly at the N-terminus, lead to enhanced stability for proteolytical degradation without adversely affecting activity. An example is given in the paper "Tritriated D-ala^1-Peptide T Binding", Smith C.S. et al., Drug Development Res. 15, pp. 371-379 (1988). Secondly, cyclic structure for stability, such as N to C interchain imides and lactams (Ede et al. in Smith and Rivier (Eds.) "Peptides: Chemistry and

Alitalo, K., Partanen, P., Vatieri, A., pp.79-86, Elsevier, Amsterdam (1985)), or by a combination of chemical and enzymatic methods if this is advantageous for the process design and economy.

[0023] A cysteine residue may be added at both the amino and carboxy terminals of the peptide, which will allow the cyclization of the peptide by the formation of a disulphide bond.

[0024] Any modifications to the peptides of the present invention which do not result in a decrease in biological activity are within the scope of the present invention.

[0025] There are numerous examples which illustrate the ability of anti-idiotypic antibodies (anti-Id Abs) to an antigen to function like that antigen in its interaction with animal cells and components of cells. Thus, anti-Id Abs to a peptide hormone antigen can have hormone-like activity and interact specifically with a mediator in the same way as the receptor does. (For a review of these properties see: Gaulton, G.N. and Greane, M.I. 1986. Idiotypic mimicry of biological receptors, Ann. Rev. Immunol. Vol. 4, pp. 253-280; Sege K. and Peterson, P.A., 1978, Use of anti-idiotypic antibodies as cell surface receptor probes, Proc. Natl. Acad. Sci. U.S.A., Vol. 75, pp. 2443-2447).

[0026] It is expected from this functional similarity of anti-Id Ab and antigen, that anti-Id Abs bearing the internal image of an antigen can induce immunity to such an antigen. (See review in Hiernaux, J.R., 1988, Idiotypic vaccines and infectious diseases, Infect. Immun., Vol. 56, pp. 1407-1413).

[0027] It is, therefore, possible to produce anti-idiotypic antibodies to the peptides of the present invention which will have similar biological activity.

[0028] Accordingly, the present invention also provides anti-idiotypic antibodies to the peptides of the present invention, the anti-idiotypic antibody being capable of inhibiting TNF toxicity, but not its binding to the receptor.

[0029] The individual specificity of antibodies resides in the structures of the peptide loops making up the Complementary Determining Regions (CDRs) of the variable domains of the antibodies. Since in general the amino acid sequence or the CDR peptides of an anti-Id Ab are not identical to or even similar to the amino acid sequence of the peptide antigen from which it was originally derived, it follows that peptides whose amino acid sequence in quite dissimilar, in certain contexts, can take up a very similar three-dimensional structure. The concept of this type of peptide, termed a "functionally equivalent sequence" or mimotope by Geyson is known. (Geyson, H.M. et al, 1987,

Strategies for epitope analysis using peptide synthesis., J. Immun. Methods, Vol. 102, pp. 259-274).

[0030] Moreover, the three-dimensional structure and function of the biologically active peptides can be simulated by other compounds, some not even peptidic in nature, but which nevertheless mimic the activity of such peptides. This field is summarized in a review by Goodman, M. (1990), (Synthesis, Spectroscopy and computer simulations in peptide research, Proc. 11th American Peptide Symposium published in Peptides-Chemistry Structure and Biology, pp. 3-29; Eds. Rivier, J.E. and Marshall, G.R. Publisher Escom).

[0031] It is also possible to produce peptide and non-peptide compounds having the same three-dimensional structure as the peptides of the present invention. These "functionally equivalent structures" or "peptide mimics" will react with antibodies raised against the peptide of the present invention and may also be capable of inhibiting TNF toxicity.

[0032] Accordingly, a further embodiment of the present invention provides a compound the three-dimensional structure of which is similar as a pharmacophore to the three-dimensional structure of the peptides of the present invention, the compound being characterized in that it reacts with antibodies raised against the peptides of the present

invention and that the compound is capable of inhibiting TNF toxicity.

[0033] More detail regarding pharmacophores can be found in Bolin et al., p. 150, Polinsky et al., p. 287, and Smith et al., p. 485, in Smith and Rivier (eds.) "Peptides: Chemistry and Biology", Escom, Leiden (1991).

[0034] All of the molecules (proteins, peptides, etc.) may be produced either by conventional chemical methods, as described herein, or by recombinant DNA methods.

[0035] All of the molecules (proteins, peptides, etc.) may be produced either by conventional chemical methods, as described herein, or by recombinant DNA methods.

[0036] The invention also provides DNA molecules encoding the ligands according to the invention, vectors containing them and host cells comprising the vectors and capable of expressing the ligands according to the invention.

[0037] The host cell may be either prokaryotic or eukaryotic.

[0038] The invention further provides DNA molecules hybridizing to the above DNA molecules and encoding ligands having the same activity.

[0039] The invention also provides pharmaceutical compositions comprising the above ligands which are useful for

treating diseases induced or caused by the effects of TNF, either endogenously produced or exogenously administered.

BRIEF DESCRIPTION OF THE DRAWINGS

[0040] Figure 1 shows a diagrammatic illustration of the bacterial constructs used for determining the sequence to which antibodies of the 32 group bind. The residues numbered 3 to 235 correspond to residues 25 to 257 of SEQ ID NO:3.

[0041] Figure 2 shows an example of the Western blotting analysis technique by which the binding of the antibodies to the constructs shown in Figure 1 have been determined.

[0042] Figures 3 & 4 show the competition of synthetic peptides whose sequences contain the region of the epitope recognized by the monoclonal antibodies of the 32 group, or parts of it, with the binding of an antibody of this group to a construct comprising part of TBP-II in which this epitope is present.

[0043] Figures 5A-5C show the nucleotide (SEQ ID NO:2) and deduced amino acid (SEQ ID NO:3) sequences of the p75 receptor. TBP-II and transmembranal domains are boxed and shaded. The region recognized by the group 32 antibodies is underlined.

[0044] Figure 6 shows the pattern of protection of HeLa p75.3 cells (as hereinafter defined) from TNF cytotoxicity by

different monoclonal antibodies against p75 TNF-R, and fragments thereof.

[0045] Figure 7 shows the effects of a monoclonal antibody against TBP-I and several against TBP--I on the extent of killing of U937 cells by TNF.

[0046] Figures 8a and 8b (hereinafter collectively referred to as Fig. 8) show the effects of monoclonal antibody 70 and Fab fragments thereof on the binding of TNF to HeLa p75.3 cells and U937 cells, respectively.

[0047] Figures 9A-9F (hereinafter collectively referred to as Fig. 9) show comparisons of the effects of the antibody 32 with other antibodies against the p75 TNF-R on TNF binding to HeLa p75.3 cells; namely MoAb #14 (Fig. 9A0, MoAb #32 (Fig. 9B), MoAb #31 (Fig. 9C), MoAb #67 (Fig. 9D), MoAb #36 (Fig. 9E) and Polyanti-stalk Ab (Fig. 9F).

[0048] Figure 10 shows dissociation of TNF from HeLa p75.3 cells in the presence and absence of antibody no. 70 and its monovalent Fab fragment.

[0049] Figures 11A and 11B show the nucleotide (SEQ ID NO:4 for #70; SEQ ID NO:6 for #32; SEQ ID NO:8 for #57) and deduced amino acid (SEQ ID NO:5 for #70; SEQ ID NO:7 for #32; SEQ ID NO:9 for #57) sequences for the CDR region of the heavy chains of three monoclonal antibodies of the 32 group.

[0050] Figure 12 shows the nucleotide (SEQ ID NO:10) and deduced amino acid (SEQ ID NO:11) sequences for the CDR region of the light chains of monoclonal antibody No. 32.

[0051] Figure 13 shows the amino acid sequence homology between several members of the TNF/NGF receptor family (residues 3-155 of hu p55 TNF-R (SEQ ID NO:12); residues 39-201 of hu p75 TNF-R (SEQ ID NO:13); residues 31-149 of hu FAS (SEQ ID NO:14); residues 3-161 of hu NGF-R (SEQ ID NO:15); residues 25-187 of hu CDw40 (SEQ ID NO:16); and residues 25-164 of rat Ox40 (SEQ ID NO:17)).

DETAILED DESCRIPTION OF THE INVENTION

[0052] TNF, as stated above, is a cytokine which initiates its effect on cell function by binding to two specific cell surface receptors: the p55 and p75 receptors. Binding of antibodies to the extracellular domain of these receptors can interfere with its effect. However, as shown in a number of studies, antibodies binding to the extracellular domain of the receptors can also trigger the effects of TNF by inducing aggregation of the p55 receptors, as well as by inducing aggregation of the p75 receptors. (Engelmann, et al. J. Biol. Chem., Vol. 265, No. 24, pp. 14497-14504, 1990; and unpublished data).

[0053] The invention relates to antibodies against TBP-II and to F(ab) fragments thereof, and to salts, functional

derivatives and/or active fractions (as defined in parent application no. 07/930,443 thereof. These antibodies provide a new approach for the modulation of the TNF activity, and may be used both to inhibit and to mimic effects of TNF on specific subsets of cells, depending on the molecular form of the antibodies, specifically on their valence: monovalent forms of the antibodies (e.g., F(ab) fragments) being inhibitory and multivalent forms being able to mimic at least part of the effects of TNF. They are, thus, suitable as pharmaceutical agents both for mimicking and blocking TNF effects on cells.

[0054] The functional interaction of the antibodies of the present invention with TBP-II provides also a new diagnostic tool, based on immunoassays such as radioimmunoassay, ELISA etc., for the detection of over- or under-production of TBP-II by cells in the body in certain disorders. Thus, the level of TBP-II in sera of patients with different types of cancer or suffering from autoimmune disorders. such as systemic lupus erythematosus (SLE), can be determined this way. In an inverse approach, antibodies against TBP-II, when produced endogenously in the body, will be measured with the use of purified TBP-II. Detecting such autoantibodies, when formed in certain autoimmune disorders, is of extreme importance, since their ability to mimic or inhibit the effects of TNF

surely has far-reaching bearing on the pathological syndromes of said disorders.

[0055] The antibodies may be either polyclonal or monoclonal. They may be raised in rabbits, mice or other animals or tissue cultured cells derived thereof or can be products of cells of human origin. They may also be produced by recombinant DNA technology either in a form identical to that of the native antibody or as chimeric molecules, constructed by recombination of antibody molecules of man and animal origins or in other forms chosen to make the antibodies most suitable for use in therapy.

[0056] For the preparation of the antibodies, either purified TBP-II or one or more synthetic peptides identical to the known sequence of a fragment thereof, e.g., to the N-terminal protein sequence, may be used to immunize animals. A further possibility is to fuse one of the possible nucleotide sequences coding for a fragment of TBP-II to the gene coding for Protein A, to express the fused Protein A-TBP-II gene in *E. coli*, to purify the fused protein by affinity chromatography on IgG SEPHAROSE (beaded agarose gel filtration matrix with broad fractionation range and high exclusion limits for the separation of biomolecules; Pharmacia) column and then to use it to immunize animals.

[0057] The monoclonal antibodies of the present invention are prepared using conventional hybridoma technique (Kohler et al. (1975) Nature 256:495; Kohler et al. (1976) Eur J Immunol 6:511). After immunization, spleen cells alone or together with lymph node cells of the immunized animals are isolated and fused with a suitable myeloma cell line. After fusion, the resulting hybridoma cells are selectively maintained in RAT medium and then cloned. The hybridoma cells obtained through such a selection are then assayed to identify clones which secrete antibodies capable of binding TBP-II. After identification, the desired clones are grown in bulk, either in suspension culture or in ascitic fluid, by injecting the cells into the peritoneum of suitable host mice. The monoclonal antibodies produced by the hybridomas are then isolated and purified.

[0058] As mentioned before, the monoclonal antibodies may also be immobilized and used for the purification of the TBP-II in affinity purification procedure using an immunoadsorbent column.

[0059] We have found that certain antibodies binding to one particular region in the p75 receptor are not mimetic but rather inhibitory to the signaling for the cytocidal effect by this receptor. This, in spite or the fact that when binding

to this region, these antibodies do not block TNF binding, but rather increase it to some extent.

[0060] The present invention reveals that this region recognized by these antibodies which we call the 32 group, is the region extending between the two C-terminal cysteines in the extracellular domain of the p75 receptor, plus an additional amino acid, thr179. This region, for simplicity's sake, is called "cysteine loop" throughout this specification.

[0061] The present invention also provides the nucleotide sequences and deduced amino acid sequences in the CDR of the heavy chain of the three antibodies belonging to this group, named 32, 57 and 70. A remarkable similarity between the sequence of amino acids in the CDR of the heavy chain of the 32 and 70 antibodies was found, indicating that the sequence of amino acids in the CDR of the heavy chain of these two antibodies is close to the optimum necessary for binding to the antigen. In addition, the invention also provides the nucleotide sequence and the deduced amino acid sequence of the light chain of antibody 32. Based on these sequences, small molecular weight compounds, peptides or mimetic compounds which will inhibit the function of the p75 receptors can be defined.

[0062] In evidence that such small compounds can indeed achieve this and that there is no need for aggregation of

receptors, which antibodies are known to be able to do, it was found that also F(ab) monovalent fragments of the antibodies of the 32 group inhibit signaling for toxicity by the p75 receptor when they are triggered by TNF.

[0063] In view of these findings, as well as the close similarity of the receptors in this particular family, this invention relates also to agents which bind to the C-terminal cysteine loop in the extracellular domain of the various other members of the TNF/NGF receptor family and modulate the function of the other receptors, similarly to the modulation of the function of TNF. In this receptor family, the localization of cysteine in the extracellular domain and the spacing is highly conserved. Certain members of this family, e.g., CDw40, exhibit particularly high similarity to the p75 receptor. Particularly in such receptors, agents binding to these regions are expected to have effects similar to the effect of the 32 antibodies on the p75 receptor.

[0064] As stated above, the ligands according to the invention may comprise proteins, peptides, immunoadhesins, antibodies or other organic compounds.

[0065] Proteins may be isolated from cellular extracts, e.g., by ligand affinity purification employing a molecule having an amino acid sequence substantially corresponding to the above-mentioned stretch as ligand.

[0066] Peptides may be prepared by synthesizing first target peptides which correspond to the amino acid stretch of the TNF-R found in accordance with the invention to bind the ligands which inhibit the effects of TNF. Thereafter, peptide libraries are screened for other ligands which bind thereto. The peptides which bind to these regions are further screened for those which also bind to TNF-R. Finally, the peptides capably of high affinity binding with both the target peptides and the TNF-R, are screened for the ability of the peptide to perform the desired biological activity.

[0067] In a similar manner, a variety of organic molecules, including drugs known for other indications, are screened for their ability to bind to the amino acid stretch found to be critical for inhibiting the effects of TNF.

[0068] In addition to the organic molecules, also broth of biological matter, such as bacteria culture products, fungi culture products, eukaryotic culture products and crude cytokine preparations, are screened with the amino acid target peptides described above. Molecules obtained by this screening are then further screened for their ability to perform the desired biological function.

[0069] Alternatively, molecules are designed which spatially fit the quaternary structure of the amino acid stretch in the receptor.

[0070] The active molecules obtained by the above procedures, insofar as they are biological substances, can also be prepared by biotechnological approaches. In this way, massive production of these molecules will be made possible. Peptides may either be produced by known peptide synthesis methods or using expression vectors containing DNA sequences encoding them. Other molecules, if produced in an enzymatic way, can be made by producing the enzymes involved in the appropriate cultured cells.

[0071] Pharmaceutical compositions containing the ligands of the present invention may be employed for antagonizing the effects of TNF in mammals.

[0072] Such compositions comprise the ligands according to the invention as their active ingredient. The pharmaceutical compositions are indicated for conditions such as septic shock, cachexia, graft-versus-host reactions, autoimmune diseases such as rheumatoid arthritis, and the like. They are also indicated for counteracting, e.g., an overdose of exogenously administered TNF.

[0073] The pharmaceutical compositions according to the invention are administered, depending on the condition to be treated, via the accepted ways of administration. For example, in the case of septic shock, intravenous administration will be preferred. The pharmaceutical

compositions may also be administered continuously, i.e., by way of infusion, or orally. The formulation and dose will depend on the condition to be treated, the route of administration and the condition and the body weight of the patient to be treated. The exact dose will be determined by the attending physician.

[0074] The pharmaceutical compositions according to the invention are prepared in the usual manner, for example, by mixing the active ingredient with pharmaceutically and physiologically acceptable carriers and/or stabilizers and/or excipients, as the case may be, and are prepared in dosage form, e.g. by lyophilization in dosage vials.

[0075] As used herein the term "muteins" refers to analogs of the proteins, peptides and the like in which one or more of the amino acid residues of the protein found to bind are replaced by different amino acid residues or are deleted, or one or more amino acid residues are added to the original sequence, without changing considerably the activity of the resulting product. These muteins are prepared by known synthesis and/or by site-directed mutagenesis techniques, or any other known technique suitable therefor.

[0076] The term "fused protein" refers to a polypeptide comprising the ligands or a mutein thereof fused with another protein which has an extended residence time in body fluids.

The ligands may thus be fused to another protein, polypeptide or the like, e.g., an immunoglobulin or a fragment thereof.

[0077] The term "salts" herein refers to both salts of carboxyl groups and to acid addition salts of amino groups of the ligands, muteins and fused proteins thereof. Salts of a carboxyl group may be formed by means known in the art and include inorganic salts, for example, sodium, calcium, ammonium, ferric or zinc salts, and the like, and salts with organic bases as those formed, for example, with amines, such as triethanolamine, arginine or lysine, piperidine, procaine and the like. Acid addition salts include, for example, salts with mineral acids such as, for example, hydrochloric acid or sulfuric acid, and salts with organic acids such as, for example, acetic acid or oxalic acid.

[0078] "Functional derivatives" as used herein cover derivatives of the ligands and their fused proteins and muteins, which may be prepared from the functional groups which occur as side chains on the residues or the N- or C-terminal groups, by means known in the art, and are included in the invention as long as they remain pharmaceutically acceptable, i.e., they cannot destroy the activity of the ligand and do not confer toxic properties on compositions containing it. These derivatives may, for example, include polyethylene glycol side-chains which .may mask antigenic

sites and extend the residence of the ligands in body fluids. Other derivatives include aliphatic esters of the carboxyl groups, amides of the carboxyl groups by reaction with ammonia or with primary or secondary amines, N-acyl derivatives of free amino groups of the amino acid residues formed with acyl moieties (e.g., alkanoyl or carbocyclic aroyl groups) or O-acyl derivatives of free hydroxyl groups (for example, that of seryl or threonyl residues) formed with acyl moieties.

[0079] The invention is illustrated by the following non-limiting examples:

EXAMPLE 1: Monoclonal Antibodies to TBP-II

Production of the Monoclonal Antibodies

[0080] Female Balb/C mice (8 weeks old) were injected with 1 μg purified TBP-II in an emulsion of complete Freund's adjuvant into the hind foot pads, and three weeks later, subcutaneously into the back in incomplete Freund's adjuvant. The other injections were given in weekly intervals, subcutaneously in PBS. Final boosts were given 4 days (i.p.) and 3 days (i.v.) before the fusion with 9.0 μg of TBP-I in PBS. Fusion was performed using NSO/Mr cells and lymphocytes prepared from both the spleen and the local lymphocytes of the hind legs as fusion partners. The hybridomas were selected in DMEM, supplemented with HAT, 15% horse serum and gentamycin 2 μg/ml. Hybridomas that were found to produce antibodies to

TBP-1 were subcloned by the limiting dilution method and injected into Balb/C mice that had been primed with pristane for the production of ascites. Immunoglobulins were isolated from the ascites by ammonium sulfate precipitation (50% saturation) and then dialyzed against PBS containing 0.02% azide. Purity was approximately 60% as estimated by analysis on SDS-PAGE and staining with Coomassie blue. The isotypes of the antibodies were defined with the use of a commercially available ELISA kit (Amersham, U.K.).

[0081] Several positive clones were obtained, subcloned for further studies and characterized. Some of the isolated subclones with their isotype and binding of TBP-II in inverted RIA are listed in Table I.

TABLE I

Subclones Producing Monoclonal Antibodies to TBP-II

Clone Number	Screening with iRIA [CPM]	Screening of subclone with iRIA [CPM]	Isotype
13.11	31800	31000	IgG_1
.12		31500	IgG_1
.13		31100	IgG_1
14.1	15300	15400	IgG_{2a}
.6		16200	IgG_{2a}
.7		15300	IgG_{2a}
20.2	12800	14200	IgG_{2b}
.5		14300	IgG_{2b}
.6		14800	IgG_{2b}
22.7	20400	20000	IgG_1
.8		19300	IgG_1
27.1	1800	27000	IgG_{2a}
.3		25000	IgG_{2a}
.9		28000	IgG_{2a}
32.4	11315	10900	IgG_{2b}
.5		10700	IgG_{2b}
.6		11200	IgG_{2b}
33.1	18400	11400	IgG_1
.3		10500	IgG_1
.4		14800	IgG_1
36.1	27500	26600	IgG_{2a}
.5		24900	IgG_{2a}
.6		24900	IgG_{2a}
41.3	13800	18100	IgG_1
.7		18100	IgG_1
.10		18800	IgG_1
67.1	16800	10900	IgG_{2a}
.16		10800	IgG_{2a}
.17		10900	IgG_{2a}
70.2	15100	5100	IgG_{2a}
.3		5200	IgG_{2a}
.4		5300	IgG_{2a}
77.2	15300	11800	IgG_{2b}
78.9	25300	21400	IgG_{2a}
82.1	17600	25900	IgG_1
.4		25700	IgG_1
.10		26400	IgG_1
86.2	8800	12200	IgG_{2b}
.5		12600	IgG_{2b}
.11		12800	IgG_{2b}
19.6		29700	IgG_{2a}
.9		28900	IgG_{2a}

[0082] Hybridomas TBP-II 13-12 and TBP-II 70-2 were deposited with the Collection Nationale de Cultures de Microorganismes (CNCM), Institut Pasteur, 25, rue du Docteur Roux, 75724 Paris CEDEX 15, France on March 12, 1990, and were assigned No. I-929 and No. I-928. respectively. Hybridoma 32-5 was deposited with the CNCM on September 1, 1993, and assigned No. I-1358. Another clone producing monoclonal antibodies to TBP-II is hybridoma 57-1,which was deposited with the CNCM on April 23, 1996, and assigned No. I-1696.

EXAMPLE 2: Inverted Radioimmunoassay (iRIA) for the Detection of the Monoclonal Antibodies to TBP-II

[0083] This assay was used for estimating the level of the anti-TBP antibodies in the sera of the immunized mice and for screening for the production of the antibodies by hybridomas. PVC, 96-well microtiter plates (Dynatech 1-220-25) were coated for 12 hr at 4°C with affinity purified goat anti mouse F(ab) immunoglobulins (Biomakor, Israel 10 μg/ml in PBS containing 0.02: NaN_3), then blocked for 2 hr at 37°C with 0.52 BSA in PBS supplemented with 0.05% TWEEN 20 (polyoxyethylene sorbitan monolaurate; Sigma) and 0.02% NaN_3 (blocking buffer) and washed 3 times with PBS containing 0.05% TWEEN 20 and 0.02% NaN_3 (washing buffer). Serum samples, in serial dilutions, or samples of hybridoma growth media (50 μl) were applied into the wells for 2 hr at 37°C. The plates were rinsed with

washing buffer and ^{125}I-labelled TBP-I (10,000 cpm, in blocking buffer) was applied into the wells. After further incubation of 2 hr at 37°C, the plates were washed and the amount of label which bound to individual wells was determined in the gamma-counter.

EXAMPLE 3: The Use of Anti-TBP-II Antibodies for Affinity Chromatography

[0084] Antibodies against TBP-II can be utilized for the purification of TBP-II by affinity chromatography, according to the following procedure. The monoclonal antibodies for affinity chromatography were selected by testing their binding capacity for the radiolabeled antigen in a solid phase radio immunoassay. Ascites from all hybridomas was purified by ammonium sulfate precipitation at 50% saturation followed by extensive dialysis against PBS. PVC 96-well plates were coated with the purified McAbs, and after blocking the plates with PBS containing 0.5% BSA, 0.05% TWEEN 20 (Sigma) and 0.02% NaN_3, the wells were incubated with 50,000 cpm ^{125}I-TNF for 2 hr at 37°C, then washed and the radioactivity which had bound to each well was quantitated in the gamma-counter. The antibodies with the highest binding capacity were examined for their performance in immunoaffinity chromatography.

[0085] Polyacryl hydrazide agarose was used as resin to immobilize the antibodies. The semipurified immunoglobulins

were concentrated and coupled to the resin as specified by Wilchek and Miron, Methods in Enzymology 34:72-76, 1979. Three monoclonal antibodies against TBP-I, clones 16, 20, and 34 were tested in these experiments. Antibody columns of 1 ml bed were constructed. Before use, all columns were subjected to 10 washes with the elusion buffer, each wash followed by neutralization with PBS. Then the columns were loaded with 120 ml of concentrated urinary proteins in PBS with 0.02% NaN_3. The flow rate of the columns was adjusted to 0.2 to 0.3 ml per minute. After loading, the columns were washed with 50 ml PBS and then eluted with a solution containing 50 mM citric acid, pH 2.5, 100 mM NaCl and 0.02% NaN_3. Fractions of 1 ml were collected. Samples of the applied urinary proteins, the last portion of the wash (1 ml) and of each elusion fraction (8 fractions of 1 ml per column) were taken and tested for protein concentration and activity in the bioassay for T3P-II. According to the protein measurements before and after coupling of the antibodies to hydrazide agarose, the amounts of immunoglobulin bound to the columns ranged from 7 to 10 mg/ml agarose. All protein measurements were done according to a micro-flurescamin method in comparison to a standard solution containing 100 μg BSA/ml (Stein, S. and Moschera. J., Methods Enzymol. 79:7-16, 1981).

EXAMPLE 4: Determination of TBP-II Using Anti-TBP-II Antibodies

[0086] The levels of TBP-II in the sera of healthy individuals, patients with cancer or systemic lupus erythematosus (SLE) and of pregnant women at term were determined by an ELISA method employing a monoclonal antibody to TBP-IO coating the plates. 50 μl of each sample was added and after a 2.5 hr incubation at 37°C the wells were washed with a solution of PBS, TWEEN 0.05% and sodium azide 0.02%, after which a rabbit anti-TBP-II polyclonal antibody was added for 2.5 hr at 37°C. Then the wells were washed again (no azide) and goat anti-rabbit horseradish peroxidase-coupled antibody was added for 2 hr. Following this incubation, and washing, an ABTS buffer was added and optical density (O.D.) read 30 min. later at 600 nm.

[0087] The normal levels of TBP-II in human serum of healthy individuals as determined by the ELISA method are 1.48 ± 0.46 ng/ml.

EXAMPLE 5: Epitope Mapping of TBP-II by Cross Competition Analysis with Monoclonal Antibodies (mAbs) to TBP-II

[0088] PVC 96-well microtiter plates were coated as described above, with purified mAbs to TBP-II (25 μg/ml). Following rinsing and blocking, samples of ^{125}I-labelled T3P-II (100,000 cpm per well) which had been preincubated for 2 hr, at 37°C with the same or a different monoclonal antibody to

TBP-II (at 1 μg/ml) were put into the wells; the plates were incubated overnight at 4°C, washed and the radioactivity bound to each well was determined by gamma counting. The results are expressed as percent of the control values (TBP-II binding in the absence of competing mAbs).

[0089] The results are depicted in Table II. The monoclonal antibodies are indicated by the clone numbers in the first row and ~n left column. Low percent binding values indicate that the two antibodies compete for each other's epitope on TBP-II, while higher values indicate that they bind to different epitopes. Non-competitive antibodies are suitable for use in double-sandwich ELISA, e.g., clones 13 and 70.

TABLE II

Cross Competition Analysis with Monoclonal Antibodies to TBP II

Competitor Antibody	Solid Phase Antibodies															
	13	14	19	20	22	27	32	33	36	41	67	70	77	78	82	86
13	4	64	53	73	31	51	161	35	177	72	131	128	77	102	50	101
14	119	20	90	13	13	84	156	11	132	173	134	113	14	70	89	179
19	103	28	7	19	11	5	144	11	144	133	179	123	18	5	85	126
20	119	17	93	14	10	88	149	9	135	170	137	135	16	70	101	181
22	109	26	94	22	13	82	128	12	115	164	136	114	17	68	98	167
27	106	23	11	27	14	8	145	17	152	133	196	136	24	8	82	125
32	150	267	150	291	156	186	14	163	139	200	205	18	294	143	103	226
33	115	19	98	23	16	86	133	12	118	156	120	114	24	78	90	155
36	155	262	168	271	144	185	167	158	12	169	223	135	265	158	93	150
41	117	119	119	118	101	109	118	76	93	9	179	107	106	111	8	9
67	112	138	125	141	125	157	136	107	138	213	30	117	120	127	106	236
70	150	246	150	255	145	166	4	162	166	217	204	6	232	132	107	234
77	121	18	98	15	13	78	148	11	145	184	142	132	18	66	103	184
78	118	20	9	26	10	6	153	13	157	137	183	131	19	6	94	172
82	107	110	130	116	112	121	128	89	90	8	162	102	121	113	8	7
86	122	181	125	166	126	129	131	120	86	18	253	109	152	125	20	17
100% value	31582	3958	2057	5437	2947	17395	25923	3525	6368	8042	4368	24113	5887	22222	11608	9703

EXAMPLE 6: Determination of the Region of the p75 Receptor which Is Recognized by the Group 32 Antibodies

[0090] We have now prepared a number of constructs by expression in *E. coli* and the complete list of constructs examined, as well as their relationship to the structure of the soluble p75R are shown in Fig. 1. Constructs recognized by the antibodies of the 32 group are listed in bold numbers and illustrated as solid lines. Those not reacting with these antibodies are listed in thin numbers and illustrated by broken lines. All constructs are identified by their N- and C-terminal amino acid residues. It can, therefore, be concluded that the epitope recognized by antibody no. 32 maps between amino acids 163-179, which corresponds to residues 185-201 of SEQ ID NO:3.

[0091] Figure 1, above the diagrammatic illustration of the constructs, shows the amino acid sequence of part of the p75 TNF-R, the regions corresponding to the soluble form of the receptor and the transmembranal region being boxed. Amino acid residues conserved between man and mouse are underlined.

EXAMPLE 7: Competition for Binding to the Extracellular Domain of the p75 TNF-R between Group 32 Antibodies and Synthetic Peptides

[0092] A number of synthetic peptides whose sequences correspond to various parts of the region on the TNF-R suspected to be the group 32 epitope were synthesized

(residues 160-179, 162-179, 163-179, 165-179 and 167-179 corresponding to residues 182-201, 184-201, 185-201, 187-201 and 189-201 of SEQ ID NO:3, respectively). The peptides were examined in an ELISA test for their ability to compete for the binding to the antibodies of the 32 group.

[0093] A bacterially produced construct corresponding to amino acids 3 to 180 of the p75 TNF-R (p75 construct in Fig. 3, corresponding to residues 25 to 202 of SEQ ID NO:3) was applied, at the indicated concentrations, to PVC plates precoated with antibody 32 followed by application of rabbit antiserum to TBP-II (p75 soluble TNF-R). The amount of rabbit antiserum bound to the plate was determined by applying goat antiserum against rabbit immunoglobulin, coupled to horseradish peroxidase and enzymatic assessment of the amount of goat immunoglobulin bound to the plate. Figure 3 shows the data of an experiment in which a synthetic peptide corresponding to amino acid residues 163 to 179 was found to compete for the binding.

[0094] Figure 4 shows the data of an experiment in which a fusion protein of maltose binding protein (TBP) with the sequence of amino acids extending from 125 to 192 of the p75 receptor (corresponding to residues 147-214 of SEQ ID NO:3) was used to coat PVC plates at a concentration or 10 μg/ml, then the No. 32 McAb was applied at a concentration of 2 μg/ml

together with the indicated concentrations of different peptides:

- DW16 - amino acids 165-179 (corresponding to residues 187 to 201 of SEQ ID NO:3)
- DW18 - amino acids 163-179 (corresponding to residues 185 to 201 of SEQ ID NO:3)
- DW19 - amino acids 162-179 (corresponding to residues 184 to 201 of SEQ ID NO:3)
- DW21 - amino acids 160-179 (corresponding to residues 160 to 179 of SEQ ID NO:3)

[0095] Thereafter, the reaction was developed by adding goat anti-mouse coupled to horseradish peroxidase. As shown in Fig. 4, marked inhibition of fusion protein recognition by monoclonal antibody No. 32 was observed only with the three peptides covering the whole epitope.

EXAMPLE 8: Mutational Study of the 32 Epitope

[0096] Replacing cysteine 178 with alanine in a recombinant peptide whose sequence corresponds to amino acids 3 to 181 (SEQ ID NO:5), made this protein unrecognizable by the 32 group antibodies. This finding suggests that in order to be recognized by these antibodies, the two cysteines in the group 32 epitope region must be free to interact with each other; i.e., that the structure recognized by the antibodies is a loop. In support of this notion, we found that reduction of

the peptide with dithiothreithol prior to SDS PAGE and Western blotting analysis somewhat decreased the effectivity of its recognition by the 32 group antibodies, and reduction by dithiothreithol followed by alkylation with iodoacetimide made it completely unrecognizable by the antibodies.

EXAMPLE 9: Effects of Various Antibodies and Fragments Thereof on TNF Toxicity

[0097] In order to compare the function of the 32 group antibodies, not only to antibodies which bind to the receptor upstream to the 32 epitope region (as most of the anti-TBP-II antibodies are expected to), but also to antibodies that bind to the receptor downstream to that epitope region, we immunized mice with a chimeric construct corresponding to the region extending downstream to the 32 epitope (amino acids 181 to 235 which corresponds to residues 203 to 257 of SEQ ID NO:3; the "stalk" region), linked to MBP. The rabbits developed antibodies which bound to the chimera with which they were immunized as well as to the intact p55 TNF receptor. These antibodies were affinity purified by binding to the chimeric protein, linked to an AFFI-GEL 10 column (crosslinked agarose matrix with N-hydroxysuccinimide as functional group; BioRad), and tested for effect on TNF function and binding. (The affinity purified antibody preparation was termed "318".)

[0098] All monoclonal anti-TBP-II antibodies as well as the affinity purified anti-stalk antibodies were tested for effect on TNF toxicity in clones of the epitheloid HeLa cells which were made to over-express the p75 receptors (by their transfection with the p75 receptor's cDNA. We called the particular over-expressing clone used in the experiments presented here, HeLa p75.3). The only antibodies found to inhibit TNF function were the antibodies of the group 32 epitope; that, in spite of the fact that they do not inhibit, but somewhat increase TNF binding to the receptor (Figs. 8 and 9). Two of the other anti-TBP-II antibodies (No. 67 of Figs. 6 and 9 and number 81) had very little effect on TNF binding to the receptor or on TNF toxicity. All other monoclonal anti-TBP-II antibodies somewhat potentiated the cytocidal effect of TNF even though competing with TNF binding (e.g., antibody 36 of Figs 6 and 9). The "anti-stalk" antibodies had very little effect on TNF binding or function (Figs. 6 and 9). Applying the anti-stalk antibodies on the cells together with antibodies of the 32 group did not interfere with the inhibitory effect of the latter on TNF function.

[0099] The same panel of antibodies was tested for effect on the killing of the myelocytic U937 cells by TNF. As opposed to the mimetic effect of anti-TNF receptor antibodies in the HeLa cells, neither anti-p55 nor anti-p75 receptor

antibodies were found to be mimetic to the cytocidal effect of TNF on the U937 cells under the conditions of the experiment carried out. Having no ability to mimic the effect of TNF, all monoclonal antibodies which compete for TNF binding either to the p75 receptor, (e.g., antibodies 14, 31 and 36 of Figure 9) or to the p55 receptor (e.g., antibody number 18 of Figure 7) are inhibitory to the TNF effects. Antibodies which had no effect on TNF binding to the receptors (e.g., number 67 of Figure 9) had no effect on TNF function (Figure 6). The 32 group antibodies were unique in having an ability to inhibit TNF function in this cell without having any inhibitory effect on TNF binding. The antibodies actually enhanced the binding of TNF to these cells, much more so than in the HeLa 075.3 cells (Figure 8). The inhibitory effect of the 32 group antibodies was additive to that of antibodies which block TNF binding to the p55 receptor (e.g., the combination 18/32 in Figure 7).

EXAMPLE 10: Effect of group 32 Antibodies and Fab Monovalent Fragments Thereof on the Dissociation of TNF from the TNF-Rs

[0100] In order to explore the mechanism by which the 32 group antibodies cause an increase in TNF binding, we compared the rate of TNF dissociation from HeLa p75.3 cells in the presence and absence of these antibodies.

[0101] Radiolabeled TNF was added to confluent HeLa p75.3 cells and the cells were incubated for 2 hr on ice. Unbound ligand was washed away and 1 ml of binding buffer containing 500 ng/ml of cold TNF was applied into quadruplicate wells for the indicated periods of time on ice. Thereafter, the wells were washed once again with cold PBS, and the amount of residual ligand was determined by measuring radioactivity of cells detached from plates by incubation with PBS/EDTA solution. The antibodies were applied throughout the assay at a concentration of 10 μg/ml.

[0102] As illustrated in Fig. 10, both these antibodies as well as their F(ab) monovalent fragments caused a decrease in the rate of TNF dissociation from the receptors. Besides providing a possible explanation for the way in which these antibodies affect THF binding to its receptors, this finding indicated an additional application for this effect. Soluble forms of the p75 TNF-Rs or of the p55 receptor or of any other member of the TNF/BGF receptor family in which a conformational change as that imposed by the 32 group antibody will occur, will serve as better inhibitors of the respective agonist.

EXAMPLE 11: Determination of Nucleotide Sequences and Deduced Amino Acid Sequences in the CDR of the Heavy Chains of Monoclonal Antibodies 32, 57 and 70 (Group 32 Antibodies) and in the CDR of the Light (Kappa) Chain of Antibody 32

[0103] In order to determine the nucleotide sequences of the CDR of the heavy chains of antibodies 32, 57 and 70, total RNA was isolated by the Promega protocol from the respective hybridoma cells, with the use of guanidinium thioisocyanate. First strand cDNA synthesis on this RNA was performed with the use of AMV reverse transcriptase and either oligo(dT)15-18 or an oligonucleotide complementary to the constant region of the heavy chain of murine IgG as a primer. The cDNA was used as a template for PCR, applying a partially degenerate 5'-Primer. 40 cycles of PCR were carried out. PCR products with the size of about 350 bp were purified electrophoretically and cloned into the Bluescript vector. Clones having inserts of the right size were sequenced. Double-stranded cDNA or the CDR region or the light chain or antibody no. 32 was synthesized in a similar manner.

[0104] The nucleotide sequences obtained by the dideoxy chain termination method, and the amino acid sequences deduced therefrom are shown in Figures 11 and 12. The CDR1, 2 and 3 regions are underlined.

EXAMPLE 12: Preparation of scFv of the 32 Group Antibodies

[0105] The cloned variable regions of the heavy and light chains of the monoclonal antibodies of the 32 group are linked with a linker of 15 amino acid length and introduced into a commercial expression vector. The vector contains a promoter, e.g., lac, a leader sequence, e.g., pel-B, as well as a, sequence encoding a small peptide ("tag" peptide) against which a monoclonal antibody is commercially available. The plasmid is now introduced into *E. coli* and the bacteria are grown to O.D. 0.5-1.0. Expression of scFv is induced by addition of IPTG and growth is continued for another 6-24 furs. The soluble scFv-tag complex is then isolated from the culture medium by immunoaffinity purification using the monoclonal antibody against the tag and then purified on a metaloaffinity column.

[0106] Any scFv accumulating within the bacteria is purified by isolating and repeatedly washing the inclusion bodies, followed by solublization by, e.g., urea or guanidinium and subsequent renaturation.

[0107] Alternative possibilities are employing an oligohistidine as the tag, using a stronger promoter instead of lac, i.e., T7, constructing the vector without the leader sequence or introducing a sequence encoding a "tail" of irrelevant sequences into the vector at the 5' end of the

scFv. This "tail" should not be biologically active, since its only purpose is the creation of a longer molecule than the native scFv, thus causing a longer retention time in the body.

EXAMPLE 13

[0108] Figure 13 shows the internal cysteine rich repeats in the extracellular domains of the two TNF-Rs and their alignment with the homologous repeats in the extracellular domain of the human FAS, nerve growth factor receptor (NGF) and CDw40, as well as rat Ox40. The amino acid sequences (one letter symbols) are aligned for maximal homology. The positions of the amino acids within the receptors are denoted in the left hand margin.

EXAMPLE 14: Creation of Recombinant DNA Molecules Comprising Nucleotide Sequences Coding for the Active Peptides and Other Molecules and Their Expression

[0109] The peptides and other molecules can also be prepared by genetic engineering techniques and their preparation encompasses all the tools used in these techniques. Thus DMA molecules are provided which comprise the nucleotide sequence coding for such peptides and other biological molecules. These DNA molecules can be genomic DNA, cDNA, synthetic DNA and a combination thereof.

[0110] Creation of DNA molecules coding for such peptides and molecules is carried out by conventional means, once the

amino acid sequence of these peptides and other molecules has been determined.

[0111] Expression of the recombinant proteins can be effected in eukaryotic cells, bacteria or yeasts, using the appropriate expression vectors. Any method known in the art may be employed.

[0112] For example, the DNA molecules coding for the peptides or other molecules obtained by the above methods are inserted into appropriately constructed expression vectors by techniques well known in the art (see Maniatis, T. et al., Molecular Cloning: Laboratory Manual, Cold Spring Harbor Laboratory, Cold Spring Harbor (1982)). Double-stranded cDNA is linked to plasmid vectors by homopolymeric tailing or by restriction linking involving the use of synthetic DNA linkers or blunt-ended ligation techniques.

[0113] DNA ligases are used to ligate the DNA molecules and undesirable joining is avoided by treatment with alkaline phosphatase.

[0114] In order to be capable of expressing a desired biological substance, i.e., a peptide or protein (hereinafter "protein", for simplicity's sake), an expression vector should comprise also specific nucleotide sequences containing transcriptional and translational regulatory information linked to the DNA coding for the desired protein in such a way

as to permit gene expression and production of the protein. First, in order for the gene to be transcribed, it must be preceded by a promoter recognizable by RNA polymerase, to which the polymerase binds and thus initiates the transcription process. There are a variety of such promoters in use, which work with different efficiencies (strong and weak promoters). They are different for prokaryotic and eukaryotic cells.

[0115] The promoters that can be used in the present invention may be either constitutive, for example, the *int* promoter of bacteriophage lamda, the *bla* promoter of the α-lactamase gene of pBR322, and the CAT promoter of the chloramphenicol acetyl transferase gene of pPR325, etc., or inducible, such as the prokaryotic promoters including the major right and left promoters of bacteriophage lambda (P_l and P_r), the *trp*, *recA*, *lacZ*, *lacI*, *ompF* and *gal* promoters of *E. coli*, or the *trp-lac* hybrid promoter, etc. (Glick, B.R. (1987) J Ind Microbiol, :277-282).

[0116] Besides the use of strong promoters to generate large quantities of mRNA, in order to achieve high levels of gene expression in prokaryotic cells, it is necessary to use also ribosome-binding sites to ensure that the mRNA is efficiently translated. One example is the Shine-Dalgarno (SD) sequence appropriately positioned from the initiation

codon and complementary to the 3'-terminal sequence of 16S RNA.

[0117] For eukaryotic hosts, different transcriptional and translational regulatory sequences may be employed, depending on the nature of the host. They may be derived from viral sources, such as adenovirus, bovine papilloma virus, Simian virus, or the like, where the regulatory signals are associated with a particular gene which has a high level of expression. Examples are the TK promoter of Herpes virus, the SV40 early promoter, the yeast gal4 gene promoter, etc. Transcriptional initiation regulatory signals may be selected which allow for repression and activation, so that expression of the genes can be modulated.

[0118] The DNA molecule comprising the nucleotide sequence coding for the peptides or other molecules of the invention and the operably linked transcriptional and translational regulatory signals is inserted into a vector which is capable of integrating the desired gene sequences into the host cell chromosome. The cells which have stably integrated the introduced DNA into their chromosomes can be selected by also introducing one or more markers which allow for selection of host cells which contain the expression vector. The marker may provide for prototrophy to an auxotropic host, biocide resistance, e.g., antibiotics, or heavy metals, such as

copper, or the like. The selectable marker gene can either be directly linked to the DNA gene sequences to be expressed, or introduced into the same cell by co-transfection. Additional elements may also be needed for optimal synthesis of single chain binding protein mRNA. These elements may include splice signals, as well as transcription promoters, enhancers, and termination signals. cDNA expression vectors incorporating such elements include those described by Okayama, H., (1983) Mol Cell Biol, 3:280.

[0119] In a preferred embodiment, the introduced DNA molecule will be incorporated into a plasmid or viral vector capable of autonomous replication in the recipient host. Factors of importance in selecting a particular plasmid or viral vector include: the ease with which recipient cells that contain the vector may be recognized and selected from those recipient cells which do not contain the vector; the number of copies of the vector which are desired in a particular host; and whether it is desirable to be able to "shuttle" the vector between host cells of different species.

[0120] Preferred prokaryotic vectors include plasmids such as these capable of replication in *E. coli*, for example, pBR322, ColEl, pSC101, pACYC 184, etc. (see Maniatis et al., (1982) op. cit.); Bacillus plasmids such as pC194, pC221, pT127, etc. (Gryczan, T., The Molecular Biology of the

Bacilli, Academic Press, NY (1982)); Streptomyces plasmids including pIJ101 (Kendall, K.J. et al., (1987) J Bacteriol 159:4177-83); Streptomyces bacteriophages such as Φ(C31 (Chater, K.F. et al., in: Sixth International Symposium on Actinomycetales Biology, (1986)), and Pseudomonas plasmids (John, J.F., et al. (1986) Rev Infect Dis 8:693-704; and Izaki, K. (1978) Jpn J Bacteriol, 33:729-742).

[0121] Preferred eukaryotic plasmids include BPV, vaccinia, SV40, 2-micron circle, etc., or their derivatives. Such plasmids are well known in the art (Botstein, D., et al. (1982) Miami Wint. Symp. 19, pp. 265-274; Broach, J.R., in: The Molecular Biology of the Yeast Saccharomyces: Life Cycle and Inheritance, Cold Spring Harbor Laboratory, Cold Spring Harbor, NY, pp. 445-470 (1981); Broach, J.R., (1982) Cell, 28:203-204; Bollon, D.P., et al. (1980) J Clin Hematol Oncol, 10:39--8; Maniatis, T., in: Cell Biology: A Comprehensive Treatise Vol. 3: Gene Expression, Academic Press, NY, pp. 563-608 (1980)).

[0122] Once the vector or DNA sequence containing the construct(s) has been prepared for expression, the DNA construct(s) may be introduced into an appropriate host cell by any of a variety of suitable means: transformation, transfection, conjugation, protoplast fusion, electroporation, calcium phosphate precipitation, direct microinjection, etc.

[0123] Host cells to be used in this invention may be either prokaryotic or eukaryotic. Preferred prokaryotic hosts include bacteria such as *E. coli*, *Bacillus*, *Streptomyces*, *Pseucomonas*, *Salmonella*, *Serratia*, etc. The most preferred prokaryotic host is *E. coli*.

[0124] Bacterial hosts of particular interest include *E. coli* K12 strain 294 (ATCC 31446), *E. coli* X1776 (ATCC 31537), *E. coli* W3110 (F^-, $lambda^-$, prototropic (ATCC 27325)), and other enterobacterium such as *Salmonella typhimurium* or *Serratia marcescens* and various *Pseudomonas* species. Under such conditions, the protein will not be glycosylated. The prokaryotic host must be compatible with the replicon and control sequences in the expression plasmid.

[0125] Preferred eukaryotic hosts are mammalian cells, e.g., human, monkey, mouse and Chinese hamster ovary (CHO) cells, because they provide post-translational modifications to prorein molecules including correct folding or glycosylation at correct sites. Also yeast cells can carry out post-translational peptide modifications including glycosylation. A number of recombinant DNA strategies exist which utilize strong promoter sequences and high copy number of plasmids which can be utilized for production of the desired proteins in yeast. Yeast recognizes leader sequences

on cloned mammalian gene products and secretes peptides bearing leader sequences (i.e., pre-peptides).

[0126] After the introduction of the vector, the host cells are grown in a selective medium, which selects for the growth of vector-containing cells. Expression of the cloned gene sequence(s) results in the production of the desired proteins.

[0127] Purification of the recombinant proteins is carried out by any one of the methods known for this purpose.

[0128] After the introduction of the vector, the host cells are grown in a selective medium, which selects for the growth of vector-containing cells. Expression of the cloned gene sequence(s) results in the production of the desired proteins.

[0129] Purification of the recombinant proteins is carried out by any one of the methods known for this purpose.

[0130] "Increased" or "substantially" increased inhibition of TNF by a ligand or soluble or mutated soluble TNF/NGF receptor means an increase over a suitable control, within experimental error, of at least one selected from the group consisting of 1, 2, 3, 4, 5, 7, 8, 9, 10, 12, 15, 20, 25, 30, 35, 40, 45, 50, 100, 200, 300, 400, 500, or 100,000 percent, or any range or value therein, such as 1000, 2000, 5000, 10,000, 20,000, 50,000, 100, 000%.